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The Effects of Cross Talk and Strong Magnetic Fields in Liquid Argon Shower Counters

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Gerhard Knies and Manfred Kobbelt

Abstract

A set of two parallel lead/liquid argon shower counters in the tower structure have been built and tested in an electron beam of energies up to 3 GeV. We have investigated the electronic cross talk and the shower leakage between the two adjoining shower towers. The electronic cross talk was in general around 1%.

Furthermore the detector was exposed to a magnetic field of 10 kGauss.

The shower signals were not affected by this field.

I. Introduction

Liquid argon shower counters are proposed for various magnetic e^+e^- storage ring detectors.

In particular they simultaneously allow for an areal segmentation like a checker board (shower towers) - to achieve a good multi-shower separation - and a longitudinal segmentation for shower growth.

Since there is considerable capacity coupling between adjacent towers, cross talk between those might be a problem. In our chamber this coupling capacity was 40 pF between two full towers. However, if the feed-back time of the charge sensitive amplifier is much shorter than the charge collection time we will have a current measurement. Thus there will be no potential build-up to induce cross talk.

A strong magnetic field affects the propagation of low energy electrons. Most of the ionization in a shower is produced by electrons of a few MeV. Does a strong magnetic field if perpendicular to the shower direction, affect the charge deposition and the charge collection and so alter the energy response and resolution ?

We have constructed a shower counter module for the purpose of measuring those effects.

II. Description of the shower counter

1. Mechanical construction

The two shower towers were constructed as a mechanical unit. The shower counter was built as a stack of 73 plates of 0.24 cm thick, 10 cm high and 20 cm wide. In each plate there were two lead converters (10 x 10 x 0.11 cm^3) glued between two copper coated fibreglass epoxy sheets (see fig. 1). The two copper surfaces (10 cm x 10 cm x 35 μm) served as electrodes. The plates were arranged to a stack with 72 gaps of 3 mm depth. The spacing was obtained by ceramic washers, and the whole stack was held together by 4 fibreglass rods (∅ = 0.6 cm).

Since there were several dE/dx gaps interleaved, the actual length of the detector was 40.9 cm and it provided 15 radiation lengths.

The device was contained in an insulated box out of 5 mm stainless steel, size 72 x 22 x 12 cm^3 (see fig. 2). The front cover had a window of 4.5 x 18.3 cm^2 with a thickness of 3 mm.

The insulation was 5 cm thick and was made out of two layers of Armaflex with a layer of superinsulation foil between. Cooling was provided by liquid nitrogen flowing through the cooling pockets (see fig. 2).

2. Signal read out

Each converter plate carried 2 quadratic copper electrodes on either side (see fig. 1). Across the gaps a high voltage of 1.5 kV was applied.

To keep capacities low enough for the amplifiers six subsequent gaps were connected serially and six such parallel series were connected in parallel[1] to form the front part. Another six series formed the back part of one tower (see fig. 3). The capacity of each sector was 250 pF (208 from the shower stack and 42 from signal lines). The signals of the four shower counter sectors, i.e. front and back part, left and right, were connected to charge-sensitive-amplifiers. The amplifier line

consisted of a charge-sensitive pre-amp., a shaping circuit, a cable driver and ADCs with 256 channels. The content of the ADC's was transfered to a PDP 11 computer.

3. Experimental set-up

Fig. 4 shows the experimental set-up. The shower counter was exposed to an electron beam at energy settings between 0.3 and 3.0 GeV. A 4-fold coincidence was used as a trigger for data taking. Measurements were done at various positions of the shower counter with respect to the beam line (see fig. 3). This was to allow for a separation of shower leakage and cross talk in the later analysis.

In a special run the detector was exposed to a magnetic field of 10 kGauss with the field direction perpendicular to the beam line and the electric field across the gaps. The beam energy was 3.0 GeV and the entrance position was # 4. In this case all detectors were connected to one amp.

4. Results

An example for the obtained pulse-height-spectra is shown in fig. 5. The cross talk signals from the neighbouring towers are given in fig. 6c - d. They are similar to the pure noise spectra (fig. 6a - b), but slightly shifted, by 0.5 channels (front) and 4.5 channels (back), respectively. When the tower exposed to the beam, was not connected to the amplifiers (virtual grounds) the cross talk was larger (fig. 6e - f).

The broadening of the shower with increasing depth caused a larger leakage in the back parts while in the front towers a separation of cross talk and shower leakage was possible as can be seen by the initial flat development of the curve in fig. 7a.

The dependence of cross talk on shower energy for the front and the back parts is shown in figs. 8, 9, 10, 11, with constant beam entrance position (# 1).

The amplifiers held down the cross talk to 1% of the direct shower signal for the front part at energies above 1 GeV. Without amplifiers grounding the struck towers, the cross talk signal was 7%.

The results of the magnetic test are shown in fig. 12. The three spectra correspond to the cases a) full field (10 kGauss), b) zero field, c) full field with opposite polarity. The shower center and the shower width are the same in all three cases. Obviously, there is no effect on the charge collection and shower development.

Acknowledgement

We are very much indebted to W. Neff who did a fine job on designing and building the charge sensitive preamplifiers. We appreciate the support we had in running and data taking by C. Berger and H. Bohring (from Aachen) and by L. Hackmack, H. Heyland, E. Glawe, A.Maniatis, D. Schmitz, K. van Staa and G. Wetjen (DESY and University Hamburg).

References

1) G. Knies and B. Neuffer, NIM 120, 1, '74

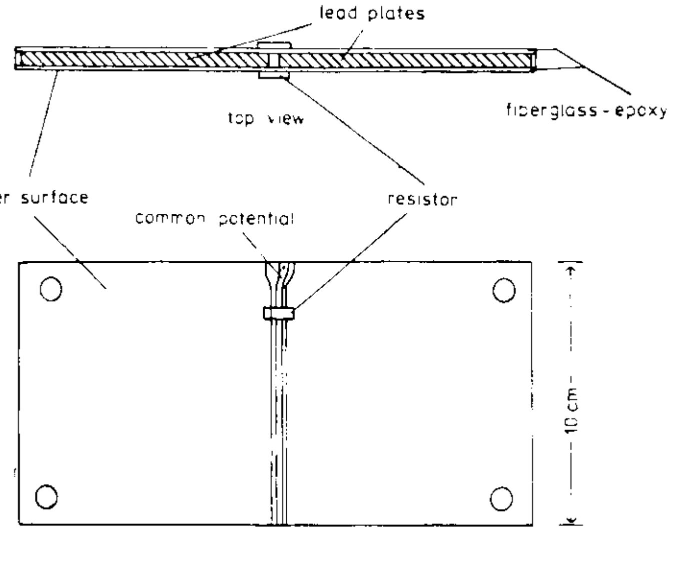


Fig 1 Converter plates

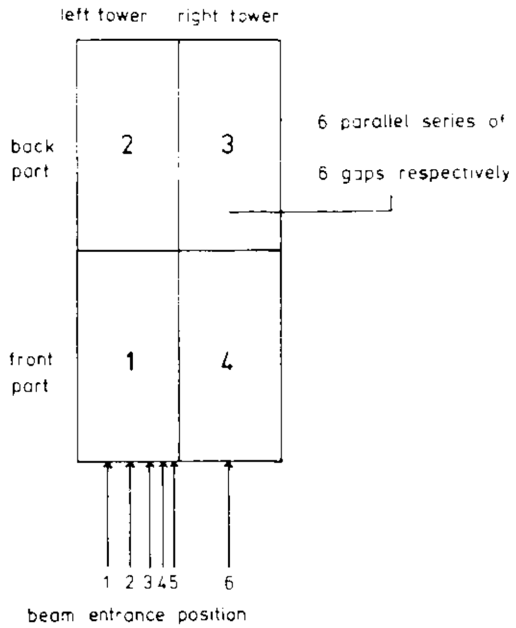


Fig.3 Top view of the shower counter sections

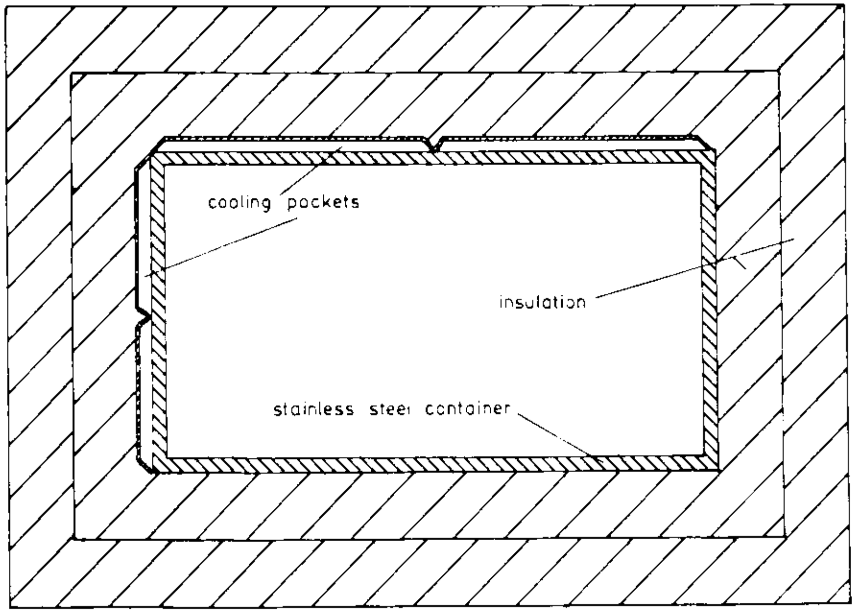


Fig 2 Insulated container (cross section)

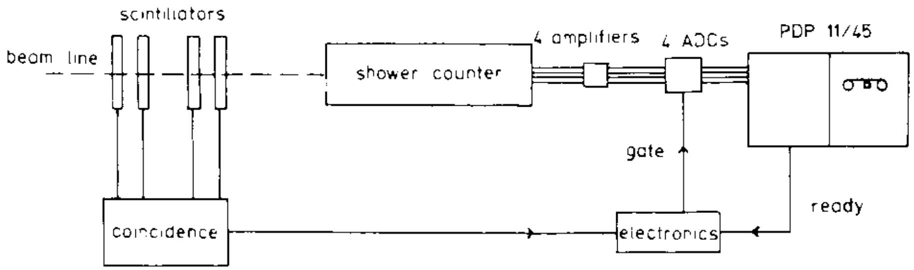
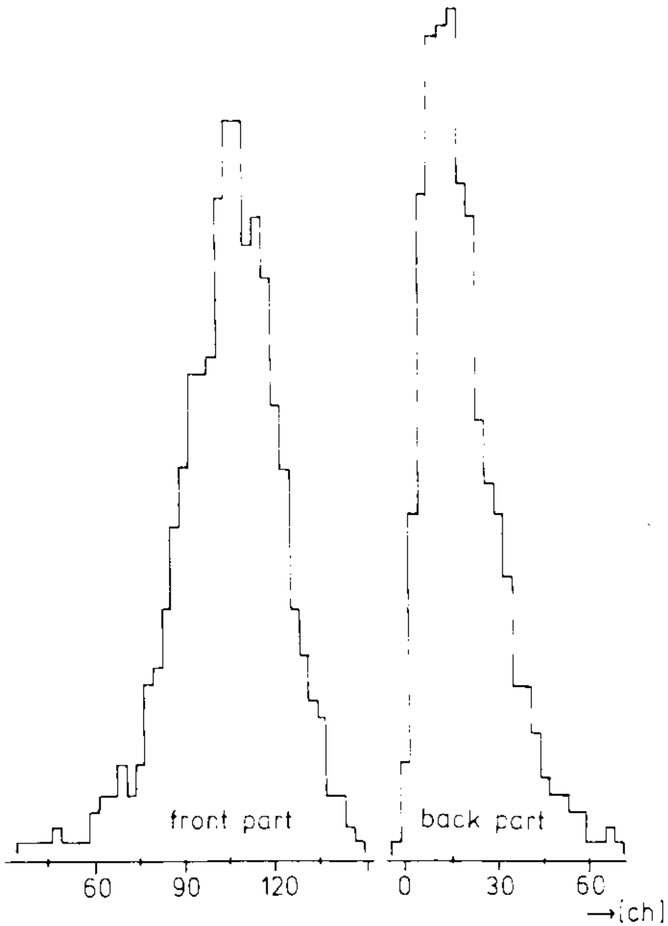


Fig. 4 Experimental set up



beam entrance position 1 beam energie 2 GeV

Fig. 5 Shower spectra

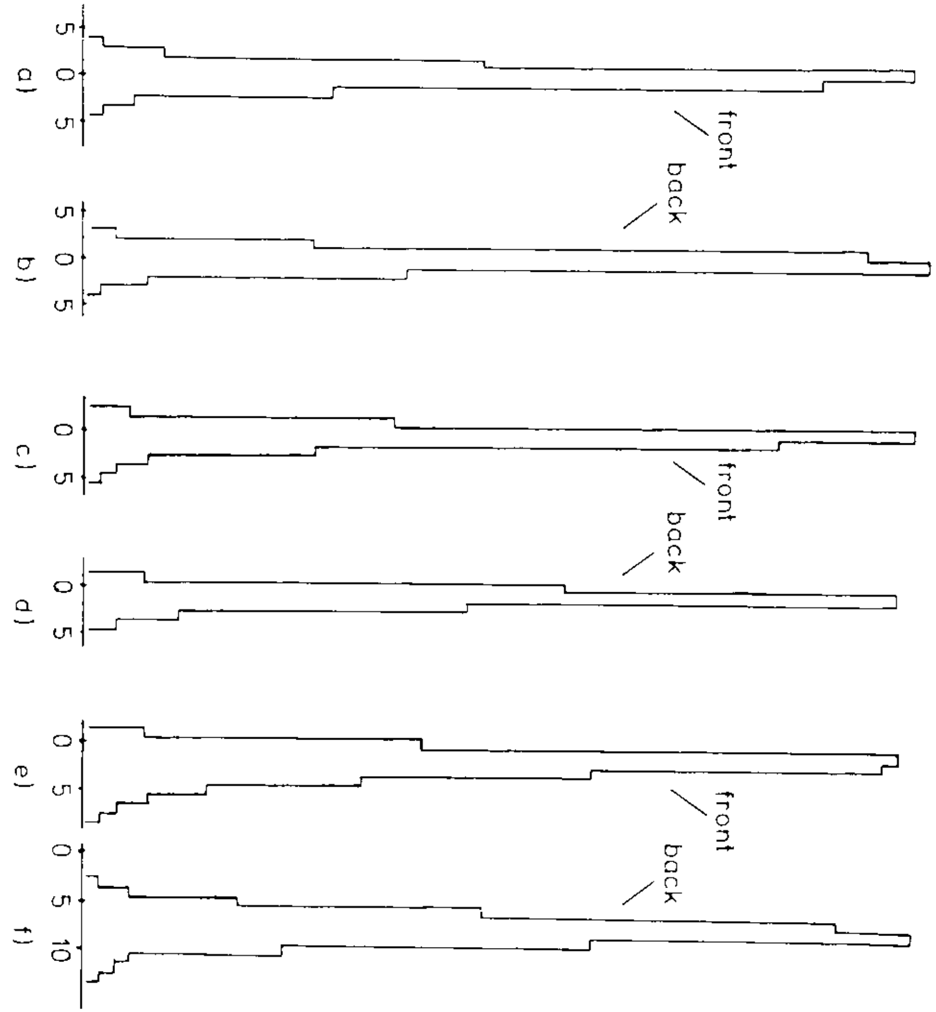


Fig. 6 Cross talk spectra; beam entrance pos 1, beam energie 2 GeV

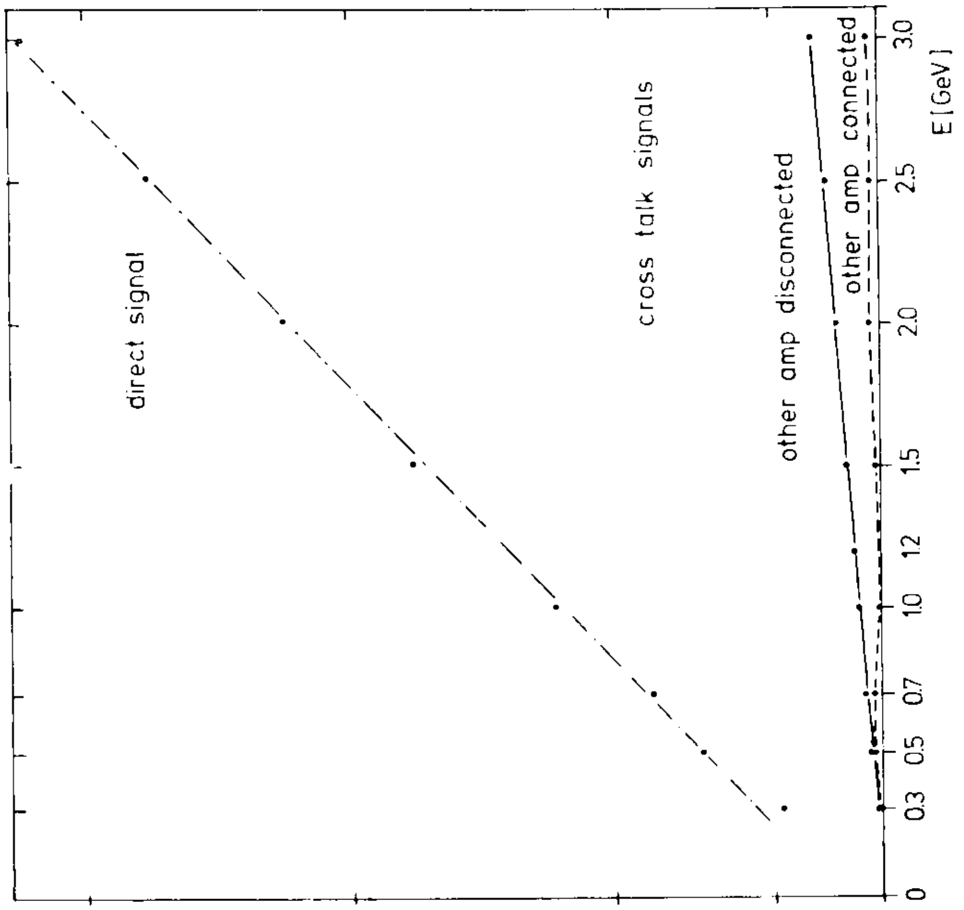


Fig. 8 Cross talk as function of shower energy. Front towers

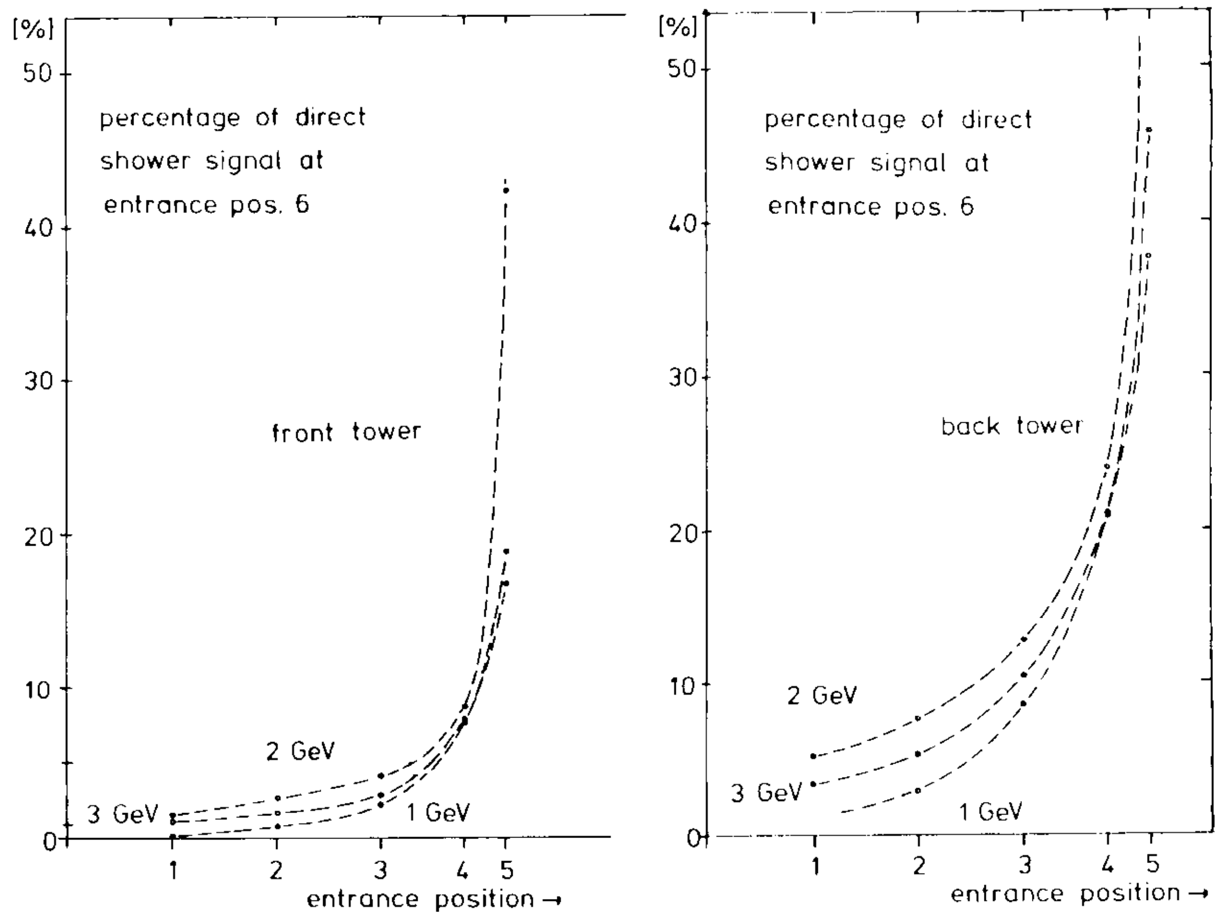


Fig. 7 Position dependence of shower leakage

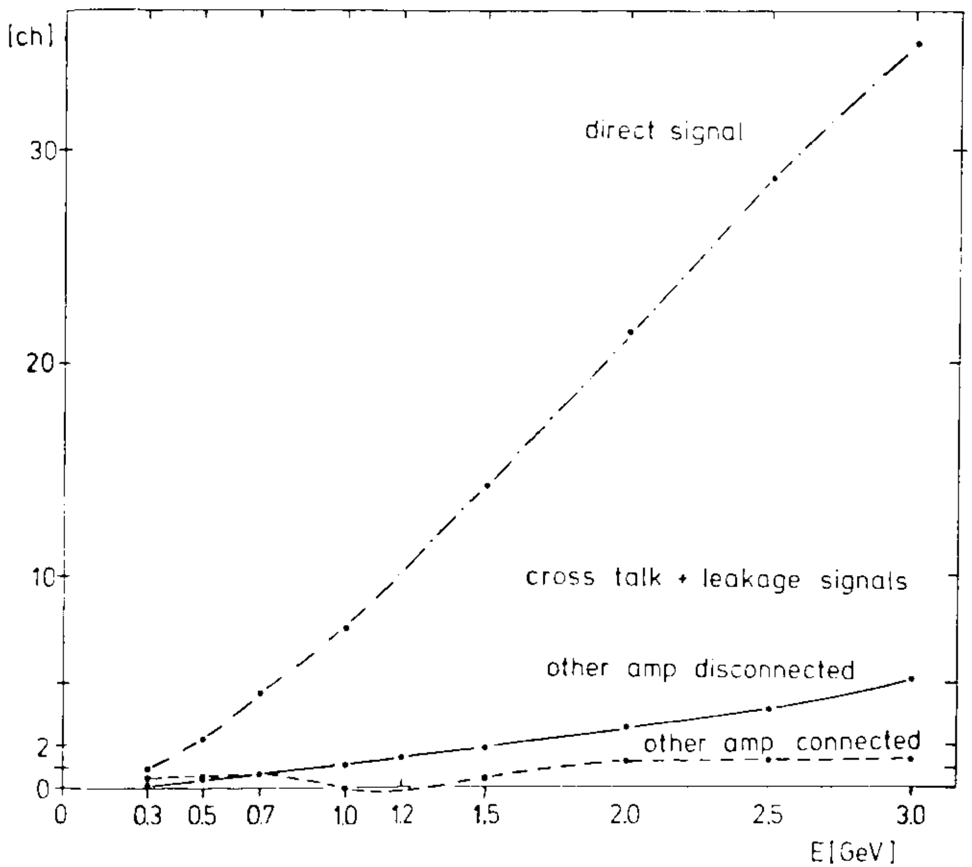


Fig 9 Cross talk and leakage in back towers

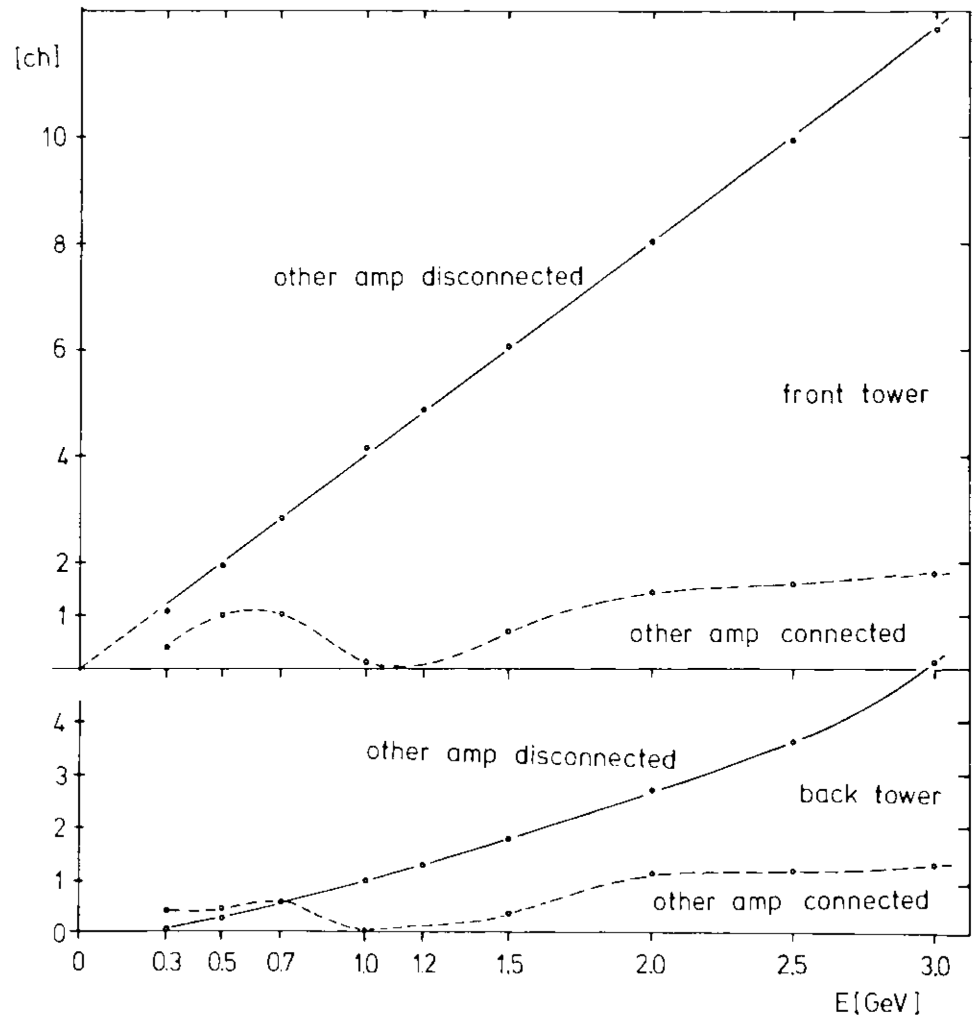


Fig.10 Cross talk (and leakage in back tower) as function of shower energy

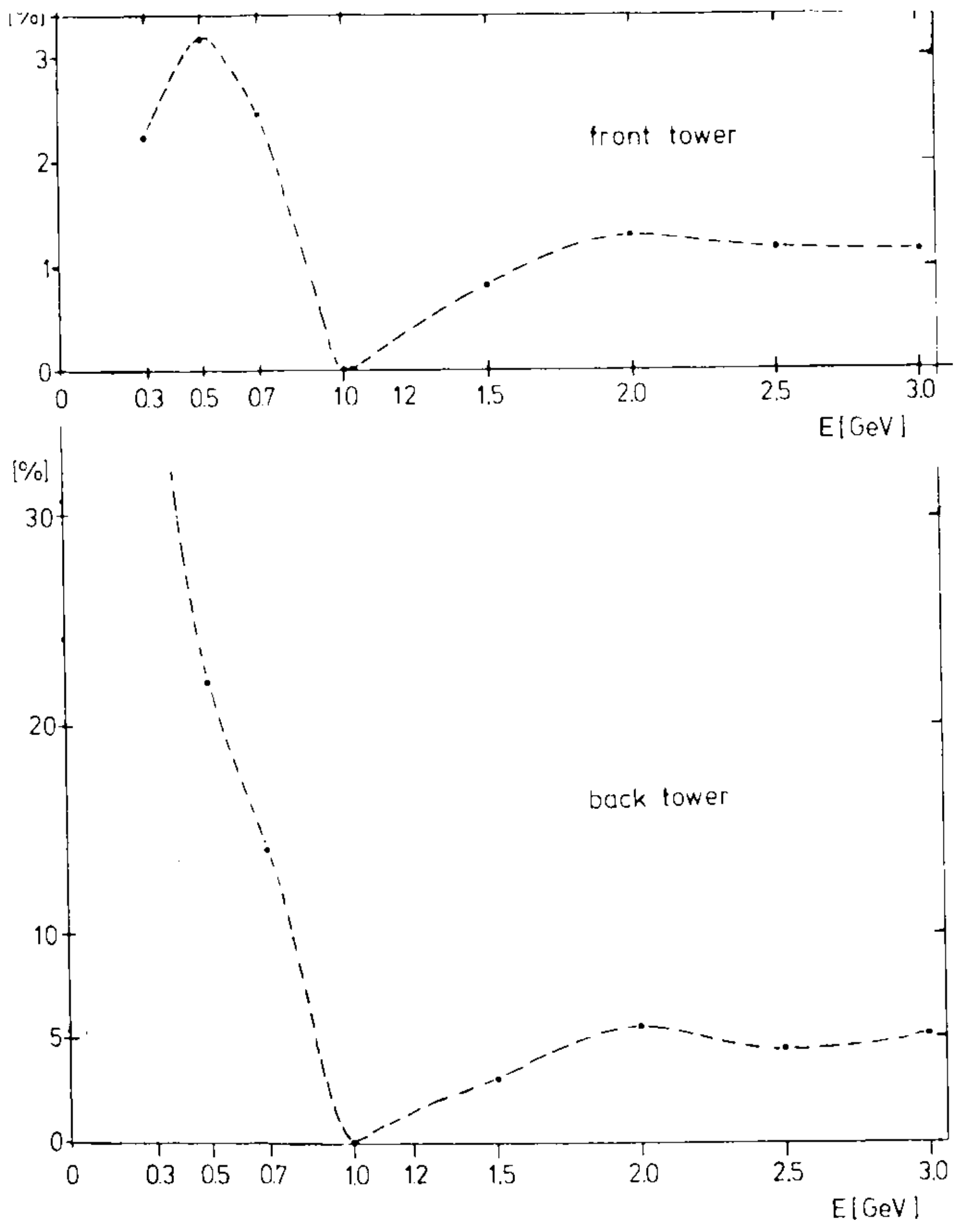


Fig. 11 Cross talk signal (and leakage signal in back tower) as percentage of direct signal, as function of shower energy

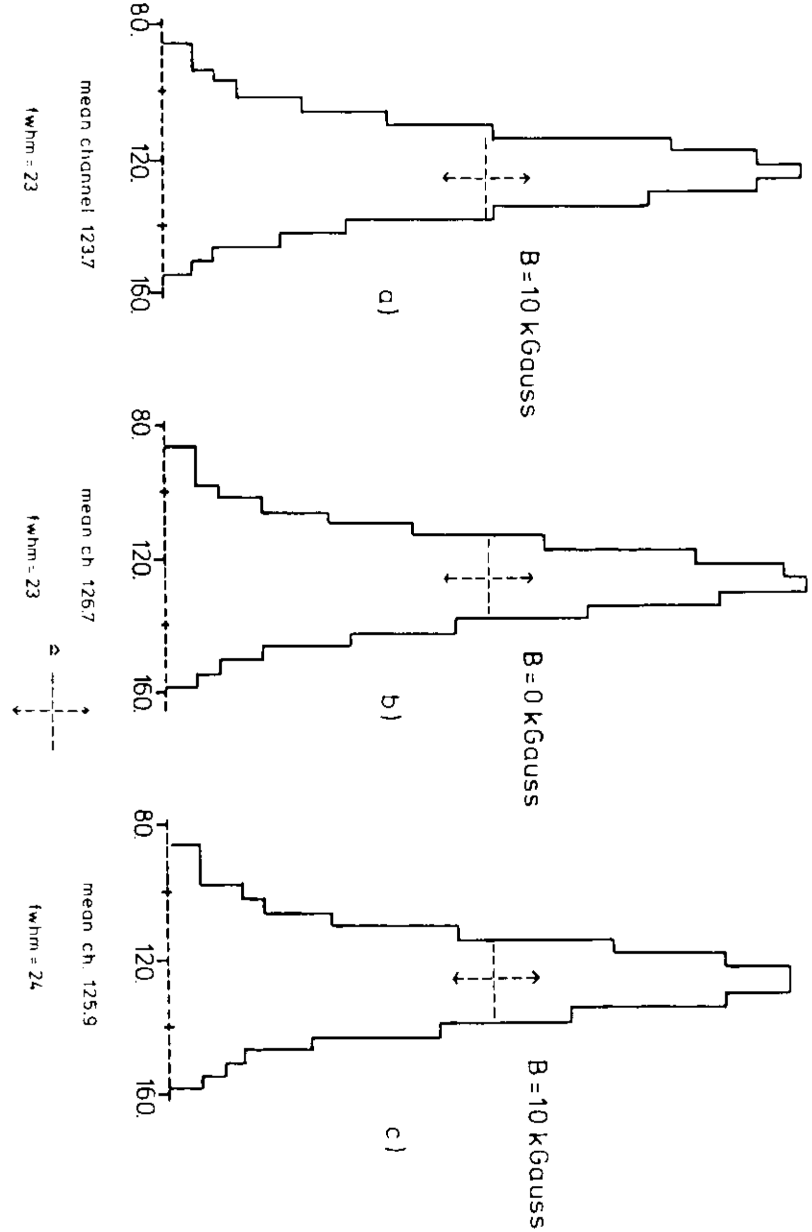


Fig.12 Shower spectrum with (a,c) and without magnetic field (b) E = 3 GeV